Studies of tropical variability

G.T. Mitchum [1], G.S.E. Lagerloef [2], A.J. Busalacchi [3]
[1] (University of South Florida, USA)
[2] (ESR, USA)
[3] (University of Maryland, USA)

This research addresses three areas of tropical ocean variability; tropical mass and heat balances, description and analysis of the tropical surface velocity field, and tropical high frequency variability. Our progress in these research areas in the tropical Pacific during the TOPEX/POSEIDON mission (including the Extended Mission) has been considerable. During the Jason-1 mission we will expand our studies to the global tropics, and also to the general problem of tropical and extra-tropical interactions.

The primary focus of this research is the role of the tropical ocean in creating and maintaining interannual to decadal climate variations. An example of such variations is the interannual El Niño Southern Oscillation (ENSO) phenomenon, although recently decadal variability has received as much, or more attention. While it is obvious that the tropical oceans are central to an understanding of the ENSO events, it is also likely that the tropics also play a significant role in longer time scale variability. Our approach to these problems involves the analysis of altimetric data and other data in conjunction with simulations by numerical models. In addition to our studies of climate variability, we also address high frequency variability in the tropics where the unique capabilities of the TOPEX/POSEIDON and Jason-1 missions allow us to obtain new perspectives on long-standing problems.

Understanding short-term (i.e., interannual to decadal) changes in our climate requires an improved understanding of the mass and heat balances of the tropics. For example, what processes maintain the western Pacific warm pool, and what is the role of ENSO events in this maintenance? What role is played by surface heat fluxes, and what role is played by tropical to extra-tropical exchanges? And how are these processes expressed in each of the different tropical ocean basins? A hypothesis due to Wyrtki [1985] emphasizes the mass and heat exchanges between the tropics and the extra-tropics during ENSO events, but this hypothesis has been controversial and difficult to test. Our basic approach to this problem is to test the in situ calculations of Wyrtki with altimetric data, and then to test numerical model simulations as well. We have had reasonable initial success in this area (figure 1) showing that the in situ estimates of tropical Pacific volume are not as complex as the patterns seen in TOPEX/POSEIDON, but the basic pattern inferred by Wyrtki appear to be reliable. We have also shown that numerical model simulations are in reasonable agreement with the altimetric data. Given the success of the numerical simulations, we are now diagnosing the causes of the tropical volume changes using the numerical model outputs. Two distinct effects have emerged; changes due to mass convergence, and those due to changes in the mean density of the tropics.

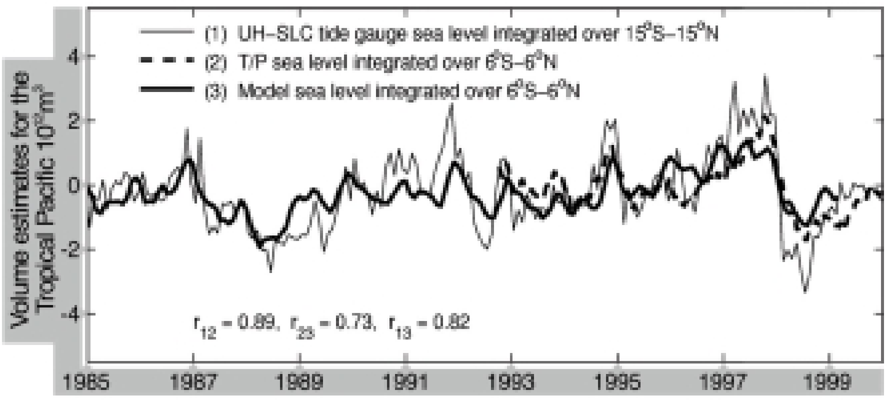

Figure 1: Tropical Pacific volume changes associated with ENSO events. The tide gauge estimate described by Wyrtki [1985] is compared to an estimate from TOPEX/POSEIDON, and to an estimate from a numerical model simulation. Good correlations are obtained, which allow us to use the numerical model output to diagnose the causes for the observed volume changes. The correlations shown are significantly different from zero at the 95% confidence level.

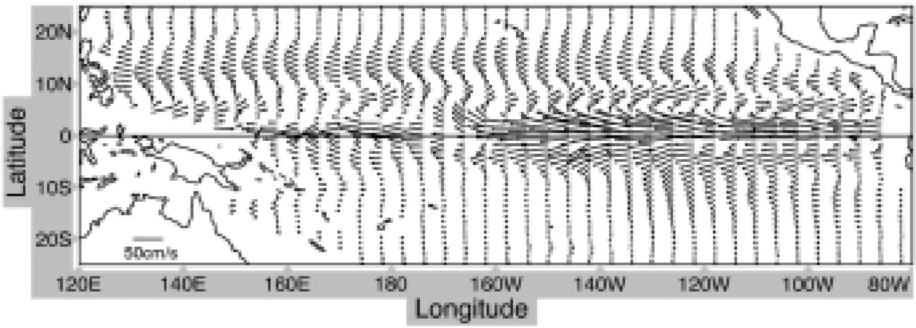

Figure 2: Satellite-derived surface current map for December 2000 from the method of Lagerloef et al. [1999], with improved techniques developed by Bonjean and Lagerloef [in preparation]. Satellite data include December 2000 TOPEX/POSEIDON sea surface height anomalies plus the mean December climatology for wind stress and SST. Data have been smoothed zonally with a 21 degree Gaussian filter.

In addition to studying the general pattern of volume changes in the tropical Pacific we have also developed a description of the surface current variations in the tropics by including the geostrophic current variations from TOPEX/POSEIDON with Ekman variations computed from scatterometry. The surface heat balance and the maintenance of the surface mixed layer in the ocean depend critically on the near surface currents, and this product directly addresses this need. Our surface current maps are tuned to reproduce the circulation measured by surface drifters. An example, shown on figure 2, is based on the method we developed during the TOPEX/POSEIDON mission [Lagerloef et al., 1999]. Our ongoing work involves a number of improvements to the basic method, an extension of our analyses to the global tropics and to the extra-tropical Pacific ocean (with an eventual expansion to a nearly global domain), and application of these observations to studies of the surface heat balance in the tropics. We are particularly interested in the heat balances of the western Pacific warm pool and the eastern Pacific cold tongue.

In addition to our studies of short-term climate variations, we are also undertaking studies of several high frequency signals in the tropics. In this portion of our research we are attempting to exploit the unprecedented spatial coverage of the altimetric data to gain a better understanding of various phenomena. In one significant example we have managed to track energetic mesoscale eddies that have been known for some time to spin up in the lee of the Big Island of Hawaii. Although these eddies have been observed for some time near Hawaii, little was known of what occurred after they propagated away from the islands. We have tracked these eddies for over 3000 km and for more than a year [Holland and Mitchum, 2001], and have managed an interesting test of existing theories of eddy propagation. In another example, we have derived a method for obtaining potential energy estimates for equatorial inertia-gravity waves from the TOPEX/POSEIDON data, despite the fact that these waves have periods of less than 5 days and amplitudes on the order to 1 cm. The ability of the altimetric measurements to observe the global modulation of the energy in the these waves on times scales on the order of a month may allow us to address a number of outstanding questions about these waves [Gilbert and Mitchum, manuscript in review at Geophys. Res. Lett.].

References

Holland C., G.T. Mitchum, 2001: Propagation of Big Island eddies, *J. Geophys. Res.*, 106, 935-944.

Lagerloef G.S.E., G.T. Mitchum, R.B. Lukas, P.P. Niiler, 1999: Tropical Pacific near-surface currents estimated from altimeter, wind, and drifter data, *J. Geophys. Res.*, 104, 23313-23326.

Wyrtki K., 1985: Water displacements in the Pacific and the genesis of El Niño cycles, *J. Geophys. Res.*, 90, 7129-7132.

Corresponding author:
Gary T. Mitchum
College of Marine Science,
University of South Florida,
140 Seventh Ave. South, St. Petersburg, FL 33701 - USA
E-mail: mitchum@marine.usf.edu